

CHAPTER 4 – RESULTS & DISCUSSION

4.1 Impact of Overripe Tempe Application as Seasoning or Toppings

Two forms of dried overripe tempe, namely overripe tempe crumbs and overripe tempe powder, were compared for their sensory acceptance. The sensory analysis involved evaluating three attributes, which are overall likeness, texture, and taste. Overripe tempe powder achieved the highest mean scores for overall likeness, texture, and taste when compared to the control and overripe tempe crumbs (Table 5).

Table 5. Sensory Acceptance Test of Instant Noodles Result

Sample	Overall Likeness	Texture	Taste ^(R)
Control	5.0 ± 1.6 ^a	5.0 ± 1.4 ^a	4.9 ± 1.4 ^a
Overripe Tempe Crumbs	5.0 ± 1.2 ^a	4.9 ± 1.4 ^a	4.9 ± 1.3 ^a
Overripe Tempe Powder	5.7 ± 1.1 ^b	5.8 ± 1.3 ^b	4.9 ± 1.3 ^a

Results are presented as mean ± standard deviation. The overall likeness score is based on a 7-point hedonic scale, 1: Dislike very much, 7: Like very much. Different letter in the same column indicate significant difference ($p < 0.05$).

During the sensory evaluation, panelists reported a notable bitter taste in samples containing overripe tempe crumbs, which also produced a distinct bitter aftertaste when bitten. In contrast to the bitter taste reported in overripe tempe crumbs samples, panelists reported no detectable bitterness in samples containing overripe tempe powder.



Overripe Tempe Powder



Overripe Tempe Crumbs

Figure 6. Overripe Tempe Powder and Overripe Tempe Crumbs Samples for Sensory Acceptance Evaluation

A literature review revealed that no prior studies were found specifically analyzing the comparative impact of overripe tempe powder and overripe tempe crumbs. But according to Mahensa Billqys Nurhayati Prativi et al. (2023), the bitterness in overripe tempe is caused by the breakdown of protein into free amino acids during the fermentation process, and as the tempe ferments and becomes overripe, more of the bitter amino acids are produced, causing a stronger bitter flavor.

Based on preliminary evaluation, the overripe tempe powder was found more acceptable due to its smaller particles. It allowed the overripe tempe powder to be uniformly integrated with the seasoning of the instant noodles, effectively masking the bitterness. In contrast, overripe tempe crumbs had larger particles. It was also separated from the seasoning of the instant noodles, causing its intense bitterness when bitten. Therefore, due to its more favorable sensory profile, with the highest result of sensory acceptance evaluation, overripe tempe powder was selected for the implementation of seasoning formulation.

4.2 Design-Expert 13 ® Trial Seasoning Formula Run With Overripe Tempe Powder

4.2.1 Seasoning to Noodle Ratio of Commercialized Instant Noodle

A preliminary evaluation was conducted to obtain the ratio of the weight of seasoning to the weight of instant noodles. The analysis of commercialized instant noodle products is shown in Table 6, which shows the seasoning-to-noodle ratio.

Table 6. Commercialized Instant Noodles Seasoning to Noodle Ratio

Instant Noodles Brand	Seasoning (g/80g noodles)
Brand A	3.56
Brand B	9.40
Brand C	9.20
Brand D	10.66
Brand E	11.60

Among the commercialized products, Brand E achieved the highest seasoning weight to noodle ratio at 11.60 grams of seasoning per 80 grams of noodle. Following the highest seasoning-to-noodle weight ratio of 11.60/80 grams, the total seasoning weight for formulation was set at 12 grams.

The seasoning formulation was done using the modified ingredients based on the base ingredients. The base ingredients consisted of salt, sugar, Monosodium Glutamate (MSG), garlic powder, and chicken powder. The modification included the substitution of MSG with yeast extract that served as a natural flavor enhancer, and the incorporation of overripe tempe powder (OTP) was done to enhance protein content and enhance umami flavor profile. Isolated soy protein (ISP) was utilized also to help increase the protein content.

4.3.2 Seasoning Formula Trial Run and Correlation of Ingredients and Response

Formulation using Design-Expert 13 ® generated 15 trial seasoning formulas run, each of which contains variations of the ingredients ratio. For each of the 15 formulas generated by Design-Expert 13 ®, several responses were analyzed, namely price and protein content. The price calculation was carried out using the price of ingredients that were not purchased for industrial and production levels, so the price obtained was more expensive. Details of the prices of the used ingredients can be seen in Table 7.

Table 7. Ingredients Price Details

Ingredients	Obtained From	Weight (g)	Price (IDR)®
Salt	Indomaret	500	7.500
Sugar	Indomaret	200	6.000
Garlic Powder	Tokopedia	1000	35.000
Chicken Powder	Tokopedia	1000	80.000
Yeast Extract	Tokopedia	500	160.000
Overripe Tempe Powder (OTP)	Rhisoya	1000	80.000
Isolated Soy Protein (ISP)	Tokopedia	1000	55.000

The prices presented were based on purchased procured between February and April 2025.

Sensory evaluation was carried out to get response data of acceptance: overall likeness, appearance, texture, and taste. Moisture content analysis was also performed to achieve the moisture content for optimization. The results obtained from the sensory test and moisture content analysis provide key data that can be used, one of which is the relationship between different response variables (Table 7).

Table 8. Coefficient of Correlation Between Ingredients and Response

Correlated Ingredients and Response	Correlation Score
Yeast Extract & Price	0.910
Overall Likeness & Taste	0.936

A positive correlation was observed between overall likeness and taste response, with a significant correlation coefficient of 0.936, indicating a close relation between the two attributes. In addition to the correlation between overall likeness and taste, the analysis revealed a significant correlation between price and yeast extract, with a correlation coefficient of 0.910. Given that yeast extract is the most expensive ingredient used for seasoning formulation, its usage directly influences the cost of the seasoning formula, revealing its impact on pricing.

4.3 Optimized Seasoning Formula

The optimization process was carried out using previously obtained response data, with protein, overall likeness, and moisture selected as the key response variables. These parameters were chosen based on their relevance to the seasoning acceptability and cost. Other sensory responses, such as appearance, texture, and taste, were excluded from the optimization process due to their weak correlations with other variables. Notably, taste was excluded because of its strong correlation with overall likeness (correlation: 0.936), which was used in the optimization. The criteria used for optimization can be seen in Table 8.

Table 9. Optimization Criteria in Design-Expert 13 ®

Response	Goal	Limits	
		Lower	Upper
Protein	In Range	6.70g	8.00g
Price	Minimize	IDR 951.53	IDR 1239.37
Overall Likeness	In Range	4.50	4.60
Moisture	Minimize	4.42%	7.91%

The overall likeness score is based on a 7-point hedonic scale.

The optimization analysis was conducted using Design-Expert 13 ®. The criteria given to Design-Expert 13 ® resulted in 8 solutions with the priority of having a low price but still maintaining an acceptable likeness. The formula that was considered to be selected is a formula that has a value close to 1, where, according to Hidayat *et al.* (2020), a good and expected optimum value was a desirability that was close to the value of 1. Two of the optimized formulas had desirability scores above 0.700 (Table 9).

Table 10. Optimized Seasoning Formula Generated by Design-Expert 13 ®

No.	Sugar (g)	Yeast Extract (g)	OTP (g)	ISP (g)	Protein (g)	Price (IDR)	Overall Likeness	Moisture (%)	Desirability
1	2.792	0.530	3.181	5.497	6.697	990.916	4.612	4.858	0.869
2	1.490	0.530	4.187	5.793	7.517	1045.180	4.687	5.245	0.718

Overall likeness columns are the average score using a 7-point hedonic scale.

The results indicated that option 2 has a higher protein content; however, this advantage was outweighed due to its higher cost compared to option 1. In contrast, option 1 came out as the superior choice due to its optimal balance of characteristics: it maintained protein content within the target range, it achieved a higher desirability score, offered a lower cost, an acceptable overall likeness score, and a lower moisture content. Based on the comparison evaluation of the parameters, option 1 was selected as the optimized seasoning formula.

In the optimized formula, there were ingredients that has impact for the response. The protein content in the seasoning formula was determined by 2 ingredients, namely overripe tempe powder (OTP) and isolated soy protein (ISP). In the selected optimized seasoning formula, OTP provides a protein content of 1.723 grams, and ISP provides a protein content of 4.947 grams. The lower amount of OTP was primarily due to its higher market price compared to ISP.

4.4 Validation of Seasoning Formula

The optimized seasoning formulation derived from the Design-Expert 13[®] requires validation to verify the accuracy of the generated predictions. Validation of high protein claim was also conducted referring to BPOM regulation No. 1 of 2022 on Control of Claims on Processed Food Labels and Advertisement. This validation process involves two analytical methods: a sensory hedonic test conducted with five identical samples to asses overall liking, and a moisture content analysis using the oven-drying method. Both analyses were performed to obtain mean values for each response prediction (Table 10).

Table 11. Optimized Seasoning Formula Response Data

Protein (g)	Price (IDR)	Overall Likeness	Moisture (%)
6.697	990.916	4.860	5.030
6.697	990.916	4.940	5.280
6.697	990.916	4.860	5.350
6.697	990.916	4.910	5.520
6.697	990.916	5.030	5.280

Overall likeness columns are the average score using a 7-point hedonic scale.

In the validation process, the mean value of response variables was calculated from five sample replicates and compared with the prediction mean from Design-Expert 13[®] (Table 11).

Table 12. Optimized Seasoning Formula Validation

Response	Predicted Mean	Predicted Median	95% PI low	Data Mean	95% PI high
Protein (g)	6.697	6.697	6.696	6.697	6.697
Price (IDR)	990.932	990.932	987.576	990.916	994.289
Overall Likeness	4.612	4.612	4.060	4.919	5.163
Moisture(%)	4.858	4.858	3.430	5.292	6.28

The validation was performed at a 95% confidence level. The validation results confirm the accuracy of the optimized reference formula (Table 9). The overall likeness score (4.919) was higher than the predicted value (4.612). The results for protein and price closely matched the predicted values. Although the final moisture content was higher than the target, it still fell in the 95% prediction interval.

Addition, with the target product consumption was for children aged 4-9 years, the protein in the seasoning may not be enough to meet the child's protein intake who consume three meals a day. With the help of the protein content from the instant noodles used for the final product, it significantly helps to meet their target protein. The 80 grams of instant noodles used provide 8 grams of protein, bringing the final product to a protein content of 14.7 grams. A comparison of the final product in this study with the recommended dietary intake (RDI) for protein content per meal for children aged 4-9 years (Kementrian Kesehatan RI, 2019) is detailed in Table 12.

Table 13. Protein Content of Final Product and RDI per Meal for Children 4-9 Years Old

Age	Daily Protein Intake/Day (g)	Protein Intake/M meal (g)	Protein in Final Product (g)	Percentage of Protein Contribution per Day
4-6 years	25	8.33	14.7	58.8%
7-9 years	40	13.33	14.7	36.75%

To qualify for a high protein claim, a product must contain a protein content at least 25% higher than existing food products. The average instant noodle contains 8 grams of protein per 80 grams, where in this study, the final product has 14.7 grams of protein, represents an 83.75% increase compared to commercial instant noodle products in Indonesia, therefore validating the final product's high protein claim.